5 SCENARIO SIMULATIONS

The following chapter applies the calibrated and validated Lake Toho ISGM to 10 different scenarios. The 10 scenarios are composed of 5 different climatic conditions each of them simulated for the normal lake regulation schedule and for the proposed lake drawdown schedule. In addition the established local model is used for 2 different scenarios to study in more details the potential impact around the Sunset Tropical fish farm located about 2 miles from Lake Toho.

5.1 Formulation of Scenarios

Table 5-1 provides an overview of the 10 scenarios for the regional model.

All scenario simulations start on November 1, 2000, using initial conditions simulated with the calibrated model. All scenarios then run until November 1, 2001 using weather data from 1996/1997 representing a normal meteorological year. Thus, on November 1, 2001 the conditions are still identical in all simulations. From November 1, 2001, the scenarios then differ both in terms of meteorological conditions and in terms of drawdown or normal lake regulation schedule as outlined in Table 5-1. Actual rainfall volumes as well as regulation schedules are illustrated as part of the result presentation for each scenario.

A. Normal Regulation	Normal Regulation (warm up)		Normal Regulation		Normal Regulation	
	START 01-Nov-00	END 01-Nov-01	START 1-Nov-01	END 31-May-02	START 1-Jun-02	END 31-Dec-03
	Meteorological data used for scenarios					
A.1 (normal/drought/drought)	01-Nov-96	31-Oct-97	1-Nov-99	31-May-00	1-Jun-98	31-Dec-99
A.2 (normal/drought/normal)	01-Nov-96	31-Oct-97	1-Nov-99	31-May-00	1-Jun-96	31-Dec-97
A.3 (normal/wet/drought)	01-Nov-96	31-Oct-97	1-Nov-94	31-May-95	1-Jun-98	31-Dec-99
A.4 (normal/normal/drought)	01-Nov-96	31-Oct-97	1-Nov-96	31-May-97	1-Jun-98	31-Dec-99
A.5 (normal/normal/normal)	01-Nov-96	31-Oct-97	1-Nov-96	31-May-97	1-Jun-96	31-Dec-97

B. Drawdown	Normal Regulation (warm up)		Drawdown		Refill	
	START 01-Nov-00	END 01-Nov-01	START 1-Nov-01	END 31-May-02	START 1-Jun-02	END 31-Dec-03
	Meteorological data used for scenarios					
B.1 (normal/drought/drought)	01-Nov-96	31-Oct-97	1-Nov-99	31-May-00	1-Jun-98	31-Dec-99
B.2 (normal/drought/normal)	01-Nov-96	31-Oct-97	1-Nov-99	31-May-00	1-Jun-96	31-Dec-97
B.3 (normal/wet/drought)	01-Nov-96	31-Oct-97	1-Nov-94	31-May-95	1-Jun-98	31-Dec-99
B.4 (normal/normal/drought)	01-Nov-96	31-Oct-97	1-Nov-96	31-May-97	1-Jun-98	31-Dec-99
B.5 (normal/normal/normal)	01-Nov-96	31-Oct-97	1-Nov-96	31-May-97	1-Jun-96	31-Dec-97

Table 5-1 Scenario Matrix Outlining the 10 scenarios for the Regional Model.

5.2 Scenario Simulation Results

The following sections describe the results of the scenario simulation in terms of water levels in Lake Toho and impacts on the groundwater table.

5.2.1 Scenario A.1 and B.1

The meteorological data for Scenario A.1 and B.1 represents normal conditions for the warm-up period and dry conditions for the drawdown as well as the recovery periods. Figure 5-1 shows the average monthly rainfall for the scenario simulation and the simulated water levels in Lake Toho for the drawdown scenario (B.1) and the normal regulation scenario (A.1). Figure 5-12 shows simulated water level in Lake Toho for all scenarios using normal regulation schedule (A scenarios) and Figure 5-13 shows simulated water levels for all drawdown scenarios (B scenarios). When the drawdown starts on November 1, 2001 the water level for scenario B.1 drops according to the drawdown schedule. When reaching the minimum scheduled water level (48.5 feet), the water continues to decrease down to about 47 feet due to evaporation depletion. When the refill process starts on June 1, 2002 the water level continues to drop until the lake starts to receive inflows in July 2002. The water level then recovers to about 50 feet where it stays until the arrival of the wet period in May/June 2003. When the lake reaches the minimum scheduled water level in March 2002 the scenario B.1 water level continues to be 3-4 feet lower than during normal regulation, until mid 2003 and the water level does not fully recover until October 2003. Full recovery here implies that the water level in the lakes reaches the same level as scenario A.1 using the normal regulation schedule. The simulated water level for scenario A.1 (normal regulation) does not reach the maximum normal regulation pool stage due to lack of inflows to the lake.

Figure 5-2 shows simulated groundwater tables at Toho1 located just next to Lake Toho, at Toho 2 located about 5000 feet from the lake in between Toho 1 and Sunset, and at Sunset Tropicals located further inland. At Toho 1 there is a clear impact from the drawdown. During the drawdown the groundwater drops almost 1 foot lower than for normal regulation. At Sunset there is no impact. At Toho 2 there is an impact on the order of 0.2-0.3 feet. At Sunset Tropicals there is hardly any impact.

Figure 5-3 shows the simulated drop in groundwater table due to the drawdown. The drawdown only affects a narrow zone around Lake Toho. This zone does not extend beyond 6000-7000 feet from the lake. None of the fish farms are located within this zone. Sunset fish farm is however located relatively close to the zone of impact and therefore the following sections focus primarily on potential impacts at Sunset.

5.2.2 Scenario A.2 and B.2

The meteorological data for Scenario A.2 and B.2 represents normal conditions for the warm-up period and dry conditions for the drawdown and normal conditions for the refill period. Figure 5-4 shows the average monthly rainfall for the scenario simulation and the simulated water levels in Lake Toho for the drawdown scenario (B.2) and the normal regulation scenario (A.2). Scenario A.2 and B.2 are identical to Scenario A.1 and B.1 until the start of the refill period in June 1, 2002. The simulated water level for scenario B.1 reaches 50 feet in September 2002 and stays between 50-50.5 feet until the start of the wet season of 2003. The lake water level fully recovers in July 2003 about 3 months earlier than for scenario B.1. The difference in the recovery period is perhaps not as significant as could be expected. The dry and the normal years, however, differ mainly in the rainfall that falls during January-April. For that period year 2000 was substantially dryer than the normal year (January-April 1997). The difference between the selected dry and normal years for the wet period is not significant.

Figure 5-5 shows simulated groundwater tables at Toho1, Toho2 and at Sunset Tropicals for Scenarios A.2 and B.2. As for scenario A.1 and B.1 there is a clear impact at Toho1, a small impact at Toho2 and no impact at Sunset Tropicals.

5.2.3 Scenario A.3 and B.3

The meteorological data for Scenario A.3 and B.3 represents normal conditions for the warm-up period, wet conditions for the drawdown and dry conditions for the refill period. Figure 5-4 shows the average monthly rainfall for the scenario simulation and the simulated water levels in Lake Toho for the drawdown scenario (B.3) and the normal regulation scenario (A.3). Scenarios A.3 and B.3 are significantly different from previous scenarios during the drawdown period. For scenario A.3 the simulated water level largely follows the normal regulation schedule while the water level for scenario B.3 drops to the scheduled 48.5 feet. Unlike scenario B.1 and B.2 the water level in the lakes does not continue to drop but stays at 48.5 feet or even slightly higher. At the beginning of the refill process the water level drops due to the drought conditions of the refill phase. The water level in the lake, however, recovers faster than for scenario B.1 due to the antecedent wet conditions for scenario B.3. For scenario B.3 the water level in Lake Toho reaches 51 feet in September 2002 while the water level in scenario B.1 did not even reach 50 feet by September 2002.

Figure 5-7 shows simulated groundwater tables at Toho1 and Sunset Tropicals for Scenario A.3 and B.3. As for the previous scenarios there is a clear impact at Toho1, a small impact at Toho 2 and no impact at Sunset Tropicals.

5.2.4 Scenario A.4 and B.4

The meteorological data for Scenario A.4 and B.4 represents normal conditions for the warm-up period, normal conditions for the drawdown period and dry conditions for the refill period. Figure 5-8 shows the average monthly rainfall for the scenario simulation and the simulated water levels in Lake Toho for the drawdown scenario (B.4) and the normal regulation scenario (A.4). The simulated water levels for scenario B.4 are not substantially different from the levels in scenario B.1 although B.1 assumed drought conditions both during the drawdown and the refill period. There are differences during the drawdown period where B.4 does not drop as low as B.1. As for A.1, the water level does not even reach normal regulation schedule. The reason is probably that the data used for the normal year (November 1996 – May 1997) represented a normal year in terms of total annual rainfall. However, in September through November where the lake goes to high pool stage there was not much more rainfall than for the dry year represented by 1999-2000 data. The refill period water levels are essentially identical to the refill period for scenario B.1 although B.4 does reach a slightly higher level in September 2002 than B.1.

Figure 5-9 shows simulated groundwater tables at Toho1, Toho2 and at Sunset Tropicals for scenario A.4 and B.4. As in previous scenarios there is a clear impact at Toho1, a small impact at Toho2 and no impact at Sunset Tropicals.

5.2.5 Scenario A.5 and B.5

The meteorological data for Scenario A.5 and B.5 represents normal conditions for the warm-up period, normal conditions for the drawdown period and normal conditions for the refill period. Figure 5-10 shows the average monthly rainfall for the scenario simulation and the simulated water levels in Lake Toho for the drawdown scenario (B.5) and the normal regulation scenario (A.5). Scenario B.5 is identical to B.2 except that B.2 assumes a drought during the drawdown. The water level in Lake Toho for the two scenarios are also similar although B.5 reaches almost 51 feet by November 2002 while B.2 only reaches 50 feet. B.5 recovers fully in May 2003 while B.2 does not recover fully until September 2003.

Figure 5-11 shows simulated groundwater tables at Toho1, Toho2 and at Sunset Tropicals for scenario A.5 and B.5. As in previous scenarios there is impact at Toho1, a small impact at Toho2 and no impact at Sunset. Figure 5-14 shows simulated groundwater tables at Toho1 and Sunset Tropicals for all drawdown scenarios (B scenarios) and the strong dependency on meteorological conditions is evident.

5.2.6 *Scenario A.1 and B.1, Local Model*

It was originally anticipated to use the local model around Fanny Bass pond to study the worst case scenario (largest impact) and the best case scenario (least impact) in more details. However, since the regional model shows zero impact at the location of Sunset Tropicals for all scenarios, the identification of "best" and "worst" case scenarios become difficult. In order to support the regional model predictions using a more detailed approach it was chosen to run the local scale model for scenario A.1 and B.1. Model boundary conditions were transferred from the regional model simulations for scenario A.1 and B.1 respectively. Initial conditions for the model was taken from the local, calibrated model on November 1, 2000 which is also the simulation start date. Figure 5-15 and Figure 5-16 shows simulated water levels in Lake Toho and simulated groundwater tables at Toho1 and Sunset for scenario A.1 and B.1, respectively.

The results are similar to those from the regional model. The water level in the lake, however, does not fully recover in 2003 as it does in the regional model. The reason is that the lake does receive smaller inflows from the western part of the lake, as this part is not included in the local scale model.

As with the regional model the simulated groundwater tables for the two scenarios shows zero impact at Sunset and a very weak impact at Toho1. The impact at Toho1 is substantially smaller than for the regional model. The reason is firstly that the local model reproduces the hydraulic gradients around the lake better than the regional model and apparently Toho 1 is now located just outside the zone of impact. As part of the model calibration the horizontal hydraulic conductivities around Toho1 were reduced from 80 feet/day to 40 feet/day. Although 40 feet/day is a relatively high hydraulic conductivity for the surficial aquifer it is probably in the low end at Toho1 and the calibrated groundwater table is also slightly higher than the observed for the local model (see Figure 4-15).

5.2.7 Scenario A.1 and B.1 With Increased Horizontal Hydraulic Conductivity, Regional Model

As described in Section 3.12 and implied in Figure 3-18, the aquifer properties become the only important parameter when the water level in Lake Toho is below 53.6 feet, at which point backwater effects in Fanny Bass Creek cease. The calibrated model already has exaggerated both the aquifer and the surface water drainage effects around Fanny Bass Pond. However, in order to assess whether the aquifer, assuming extreme hydraulic aquifer properties, would enable the drawdown zone to extend as far as the location of Sunset Tropicals, two sensitivity runs were made for scenarios A.1 and B.1. The key parameter determining the extent of the impact zone is the horizontal hydraulic conductivity of the aquifer. For the calibrated model the horizontal hydraulic conductivity around Toho 1, Toho 2 and Sunset is on the order of 75-125 feet/day. These values are probably already at the upper limit for hydraulic properties of the surficial aquifer. For scenarios A.1 and B.1 the calibrated horizontal conductivities were multiplied by a factor 2 and 5, respectively. A multiplication factor of 5 increases the values around Fanny Bass Pond to the order of 500-600 feet/day. These properties correspond to coarse sand or gravel sediments and are far beyond the realistic levels for the sandy/silty surficial aquifer system, which exists in the area. Results of these two sensitivity simulations are shown in Figure 5-17 and Figure 5-18.

For the extreme situation where the horizontal hydraulic conductivity have been increased with a factor 5 (see Figure 5-18) a small impact at Sunset is simulated. The maximum impact at Sunset occurs in the middle of 2003, during the lake refill period, and is in the order of 0.3 feet. The impact at Toho 1 reaches 1.3 feet, when the lake water level reaches the minimum level in August/September 2002. At Toho2, which is located around 5000 feet from the edge of Lake Toho, the simulated impact does not exceed 0.5 foot. If the horizontal hydraulic conductivity is multiplied with a factor of 2 there is only a very small impact at Sunset with a maximum of approximately 0.15 feet.